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ABSTRACT

The school counselor is forced to make important decisions in predicting student success. He makes these decisions, correctly or incorrectly, based on available data pertaining to that student. This two part study sought to determine the advantages of using a computer for handling information and making predictions and to see whether the counselor would properly challenge computer predictions. Thus, ten junior high counselors supplied with corresponding computer predictions were asked to predict success in algebra for 100 anonymous eighth-grade students. Multiple linear regression analysis revealed that counselors tend to be optimistic in their predictions but that they were not unduly influenced by the computer predictions. A related document is available as ED 017 710. (JS)

TM-4409

TECHNICAL MEMORANDUM

(TM Series)

Final Report

The research reported herein was performed pursuant to Grant No. OEG-9-8-071229-0122(085), Project No. 7-1229, with the Office of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

IMPLEMENTATION OF VOCATIONAL COUNSELING SYSTEM

by

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15 September 1969

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SUMMARY

The purpose of the project was to continue and complete the development and evaluation of the man-machine counseling system that was designed as part of the USOE-supported Project No. 141-65, "Exploratory Study of Information Processing and Computer Technology in Vocational Counseling." The computer system was designed for on-line use by secondary school counselors and would have operated on a large, time-sharing computer. Counselors would communicate with the system through teletypes located in the schools. Some major parts of the system were:

1. Storage and retrieval of student information.
2. Calculation routines.
3. Prediction routines
4. Automatic tracking and monitoring of student progress.
5. Automated interviews.
6. Automated individualized letters or reports to students.

Counselors at two Los Angeles schools had been intimately involved in the design phases of this system and were to be involved in further development, installation, evaluation and revision. They were also engaged in training in group and individual counseling techniques and other activities intended to prevent their becoming too machine or data oriented. Funding for this project was discontinued, however, before the work could be completed.

Those parts of the computer system which had been programmed prior to the termination of the project encouraged belief that the system would have been powerful and useful, even for naive users.

I. INTRODUCTION

The purpose of this study was to continue and complete the development and evaluation of the man-machine counseling system designed as part of the USOE-supported Project No. 141-65; entitled "Exploratory Study of Information Processing and Computer Technology in Vocational Counseling." Originally planned as a 28-month project, the major goals of the study had to be abandoned as the result of funding reductions at the U. S. Office of Education. In order to make use of what funds did remain, we proposed to USOE that we modify our plans to allow us to do a useful piece of work with the remaining funds. The modified plan was for an investigation of the effects of computer prediction on counselor prediction of student success. The proposal was accepted and the investigation was conducted. It is described in another document, "Computer Prediction and Counselor Prediction," TM-4410. The purpose of this report is to describe the state of the project at the point when it was terminated. Most of the work on this project was conducted under a previous contract. For a detailed description of that effort, the reader is referred to two System Development Corporation documents: TM-2582/000/00 and TM-3718.

II. COMPUTER SYSTEM OBJECTIVES

The general objective was to develop and evaluate a man-machine counseling system in a junior high school and a high school in Los Angeles, California. The computer system was to be designed for on-line use by counselors, and would

operate on a large time-shared computer. Counselors would communicate with the system through teletypes located at the schools. Although the teletype would be the customary mode of input and output, card readers and line printers would be used for bulk input or output when desired. The following computer functions were to be implemented:

1. Student Information Storage and Retrieval

Capability was to be provided for on-line (or off-line) data description, storage, and retrieval.

a. Data Description. The system would set up data bases of items as named and described by the user, and new items could be named, described, and added to existing data bases constructed by the system.

b. Data Storage. Data-storage statements prepare the program for the input of data into the data base. They specify the students and name the items to be stored. Input data will be checked against the data description and faulty inputs will be reported.

c. Data Retrieval. The user would employ data retrieval statements to specify the data desired and the population of students whose records should be searched. Such requests would be made either by teletype or by punched card. The retrieved data may be output on either the teletype or the high-speed printer. Retrieval statements could be used to inspect data in the data base, or in conjunction with calculation functions and form descriptions (see below) to generate reports.

d. Input and Output Forms. At certain times it would be necessary to read in or print out large amounts of data using certain prespecified formats. Some cases of input are: initial loading of the data base from cards; recording students' marks for the 15th-week progress reports; teachers' recommendations of candidates for reading classes. Some output examples are progress reports, program cards, and the total cum.

2. Define Statements

A define statement is a means whereby the user may make certain kinds of changes in the language in order to simplify frequently used expressions, to satisfy idiosyncratic desires, or to make the language more English-like (and, hence, easier to teach and use). It is a string-substitution device that, in conjunction with the structure of the basic language, can make a great contribution to ease of use.

3. Calculation Routines

The counselor would be able to use the computer to perform arithmetic and logical operations on data in the data base, or as a very powerful "desk calculator." Calculation phrases may be used within retrieval statements to produce "derived" data.

4. Prediction Routines

Part of a counselor's job is anticipating what might or might not happen to his students at some future time. This, of course, is a prediction problem. However, not all counselors are well versed in prediction and statistics. Prediction routines would be provided to satisfy the needs of those counselors who do not remember their statistics courses, as well as for those who do. In order to predict, it is only necessary that the user specify the criterion variable, the predictor variables, and a population. A prediction formula would then be computed and retained for later use. Prediction formulas may be called upon by name for application to individual students.

5. Tracking and Monitoring

Tracking and monitoring is a special case of retrieval. In general, these routines would be used for information about situations that (1) occur infrequently, (2) have potentially serious consequences, and (3) may pass unnoticed until they result in disaster for a student. A tracking and monitoring statement is, basically, a retrieval statement that continues to remain in force until it is deleted. Any time there are data satisfying the retrieval request, they will be reported automatically.

6. Reminder Secretary

The reminder secretary routine would permit the counselor to store messages to be typed out for him at a later time of his choosing.

7. Automated "Interviews"

Automated "interviews" for student use were to be developed within the PLANIT (Programming LANguage for Interactive Teaching) system.[1] Because the number of terminals to be installed at each school was small, few students could have been accommodated and consequently the use of the interviews was to be experimental only. PLANIT was also to have been used to prepare individualized letters or reports for students. Because this use does not require student interaction at a terminal, it was not to be restricted to experimental explorations.

III. HUMANISTIC OBJECTIVES

The computer system was to be used by people in a strongly interactive mode. Therefore, it was important to pay attention to the needs, desires, and limitations of the intended users while designing, implementing, and revising the system. Consequently, there was a set of humanistic objectives to guide development of the system:

1. The computer system should be implemented with the individual user (counselor) in mind. The language and procedures provided for

[1] Feingold, S. L., and Frye, C. H. User's Guide to PLANIT. SDC document TM-3055/000/01. October 17, 1966. 214 pp.

communication between the user and the system should be as natural as possible, so that they would be easy to team and easy to use. Furthermore, they should be modifiable by the user to meet his individual needs.

2. The counselors should be made aware of the possible dangers involved in using computers in the counseling operation, including such problems as safegarding the privacy of information, overvaluation of computer-generated data or statistical prodictions, and the possible decrease of contact between counselors and students.

3. The research team should meet frequently with the counselors to obtain feedback on system problems so that necessary changes can be made.

4. Counselors should improve their communication with each other, teachers, the administration, and especially with the students. The counselors should be trained in group and individual counseling techniques and would periodically be given the results of student questionnairs covering students' problems, feelings, and attitudes.

5. Changes in counselors' attitudes and behavior should be assessed by collecting data from questionnaires and time logs, and the findings should be discussed with the counselors periodically.

IV. RESULTS

A. THE COMPUTER SYSTEM

The exact workings of many parts of an information retrieval system depend on the structure chosen for the data base.* One cannot even flowchart a data base-generation program, for example, until one knows what files, tables, pointers, and so on, will be required--that is, how the data are to be organized. Thus the programming of an information retrieval system is generally not begun until a data-base structure is chosen.

The problems involved in choosing or inventing a data-base structure for our system stemmed from the desire for rapid response on a very large data base. The system projected by our final report of Phase I ideally should have response times of a few seconds even for the most difficult queries. Such speeds require that the data base be "inverted" on every value of every item in the data base. This means that the data base must contain a list of all the cumulative records that have a value of "A12" for the item CLASS and another list of all cums that

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*We use the term "data base" here to mean the data stored in the computer and the accompanying "bookkeeping" devices (tables, pointers, etc.) whose purpose is to facilitate the retrieval of data.

have a value of "B12" for CLASS, and so on for all existing values of CLASS. Similar lists must be provided for all other items in the data base; in fact, lists must be prepared for every item-value pair (such pairs are called keys) that could conceivably be needed for a counselor's queries. The entire cumulative folder, except for anecdotal information, consists of such keys. Thus, this problem differs from the text-retrieval problem in which a large body of information (the texts) is stored, but inversion is done only for "Keywords," which, even if relatively numerous, will still be only a small fraction of the total data.

To the best of our knowledge, no existing information retrieval system could give rapid response for the kind of data our counselors would be concerned with. Building such a system would have been a very big job, requiring considerable man-hours and computer time. Budgetary and manning problems militated against our following the obvious, logical process of designing the data base first. Certain parts of our information system, however, particularly those dealing with user input, are independent of data base. Consequently, it was possible to design, program, and check out some system routines without a detailed data base design. Some of these parts were:

- General input and output routines
- Item definition
- The Define function (and the associated Translate and Cancel functions)
- The translation of the input query into an equivalent query couched entirely in primitives of the language
- Checking of the grammar and punctuation of the query
- Converting the population and the adjectives of the direct object into conjunctive normal form

Working on these routines first offered certain advantages. In the first place, it was possible to do the work with limited manpower and limited computer usage. Secondly, early development of these routines would make possible earlier counselor involvement with the system. The training of the counselors in the use of the language could be facilitated by processing their exercises through part of the system. Finally, these routines could be used with a simple, uninverted data-base structure, which, while slower in operation, would be implemented sooner. Eventual transition to an inverted data base would require little or no retraining of the counselors.

When work on the computer system was discontinued, enough of the subsystems were implemented to give one a fairly good idea of what the total system would look like to the user. One could, for example, perform the following functions on-line: describe a data-base (i.e., name and define items to be used), enter complicated

retrieval statements, and use the Define, Translate, and Cancel commands. All user statements were decoded and checked for erros. However, because the data base structure had not been developed, storage and retrieval of data were not possible.

B. THE HUMANISTIC APPROACH

We felt that the humanistic approach taken in this project could effect desirable changes in the educational process. The results of this approach were very encouraging. The counselors appeared to be changing their values in desired directions. They were concentrating less on data and more on students as human beings. They were concerned with the misuse of automation as well as with its advantages in efficiency. They seemed to believe that real, meaningful change could occur, and that they could help to bring it about.

In summary, although the unavailability of funds prevented us from exploring fully the use of computers in educational counseling, we did gain some prelimenary evidence that they can be used. We also feel their use must be carefully directed, lest they be used to simply mechanize the shortcomings that already exist in the educational system.

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Final Report

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COMPUTER PREDICTION AND COUNSELOR PREDICTION SYSTEM

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SUMMARY

This final report describes the results of a study of how junior high school counselors' predictions of students' success in mathematics might be affected by the counselors' knowing what success has been predicted for those students by a computer. The purpose of the study was to throw some light on the general question of whether the "judgments" of a computer are viewed as possessing some unchallengeable authority over human judgments in similar situations. Ten experienced junior high school counselors were asked to predict the degrees of success in ninth-grade algebra of 100 anonymous eighth-grade students on the basis of cumulative records and some additional information. The additional information included other predictions of the students' success in ninth-grade algebra. Some of these predictions were clearly identified as having been made by a computer; the remainder were prepared as if they had been made and recorded by another counselor. Both sets of predictions were further divided into optimistic and pessimistic predictions. Five treatments were then used: (1) cumulative record only, (2) cumulative record and an optimistic "computer" prediction, (3) cumulative record and pessimistic "computer" prediction, (4) cumulative record and an optimistic "head counselor" prediction, and (5) cumulative record and a pessimistic "head counselor" prediction.

After the counselor subjects had made their predictions, multiple linear regression analysis was performed on the prediction data to examine the differences among the five treatments. Three null hypotheses were tested: (1) that there would be no differences in the subjects' predictions among the five treatments; (2) that there would be no differences in the subjects' predictions due to their having been given either optimistic or pessimistic predictions; and (3) that there would be no differences among their predictions due to their having been given a computer's or a counselor's predictions. Hypotheses (1) and (2) were rejected. Hypothesis (3) was not rejected. The results showed that the subjects tended, in general, to make optimistic predictions, that they were swayed differently by optimistic and pessimistic predictions, but that they were not swayed differently by knowing that a computer or another counselor had made an earlier prediction. In general, then, we concluded that the notion that the computer exercises an unexamined authority, or sway, over counselors' use of their own experience and skills in making predictions is not borne out. The study did, however, raise some ancillary questions regarding the possibly undue influence of grading practices on students' scholastic careers.

I. PROBLEM

Research and development in the area of computer applications in secondary school counseling is growing rapidly. Although the computer can be helpful in counseling and guidance, however, it can also be misused, and its misuse can lead to undesirable consequences in the counseling operation. Therefore, while we should employ the resource of the computer for help in counseling, we should be sure that this resource is being properly used.

At System Development Corporation, some of our past work in computer assisted counseling has led us to believe that apparently scientific or authoritative predictions of student success can materially influence the appraisal that school people (teachers, counselors, etc.) make of students. Since those who do not work intimately with computers may think of them as being particularly scientific and authoritative, the answers or predictions produced by a computer in counseling may be very powerful. We should be very careful, therefore, about the nature of the computer prediction models used in counseling. If computer predictions, however accurate, might lead counselors to make bad predictions, on a wide scale, we will not only have misused the computer, but we may also have squandered the human resources available to us. "Bad" predictions are not simply inaccurate predictions, but predictions that may lead to suppressing human potential.

The purpose of this study was to investigate the effects of computer predictions on the predictions made by junior high school counselors. In particular, the study was intended to determine whether or not a counselor's knowledge of a computer's predictions of student success (or failure) can influence his own predictions about students. Do optimistic computer predictions lead the counselor to make more optimistic predictions than he might otherwise make? Are a counselor's predictions swayed in a pessimistic direction by pessimistic computer predictions? Are some counselors so opposed to the idea of using computers in counseling that computer predictions actually influence them to make predictions that tend in the opposite direction? Furthermore, does the knowledge of predictions made by other experienced counselors affect counselors' predictions and, if so, is such knowledge more or less influential than a knowledge of computer predictions?

II. PROCEDURES

Generation of Cumulative Records

Ten experienced junior high school counselors were asked to predict the degree of success in ninth-grade algebra of 100 eighth-grade students who were unknown to the counselors. The counselors were asked to make their predictions on the basis of student data--cumulative records ("cums") and some additional information--supplied to them. The cumulative records, although based on real data, were generated in such a way as to create five sets of matched cums:

1. Cumulative record only (Differential Aptitude Test (DAT) scores and courses and marks).

2. Cumulative record and an optimistic "computer" prediction.

3. Cumulative record and a pessimistic "computer" prediction .

4. Cumulative record and an optimistic "Head Counselor" prediction .

5. Cumulative record and a pessimistic "Head Counselor" prediction .

Twenty real junior high school cums were selected according to three criteria:

1. Each cum was for a student who took algebra in the ninth grade.

2. The algebra marks were distributed as follows: 4 B's, 12 C's, and 4 D's.

3. Within the 20 cums there was a considerable range on such relevant variables as GPA, 7th and 8th grade math marks, the DAT scores.

From each high school cum so selected, five new cums were generated according to the following rules:

1. The cums were restricted to information for grades 7 and 8, and consisted of student number, courses and marks for the 7th and 8th grades, and DAT percentiles for verbal reasoning, mechanical reasoning, sentences, number ability, abstract reasoning, spatial relations, clerical, spelling, and combined verbal reasoning and number ability.

2. The student name was eliminated and student number was different on each generated cum.

3. Because the 20 cums were chosen from three different junior high schools, the names of similar courses might differ. These names were changed to achieve uniformity.

Generation of Additional Information

The additional information ("computer" predictions and "head counselor" predictions) was generated from the original 20 students' actual algebra marks. The optimistic predictions were made by adjusting all of the student's marks up one mark (B became A, C became B, etc.); pessimistic predictions were made by lowering the marks (B became C, etc.).

Each abbreviated cum was printed (by computer) on one page of computer paper. "Computer" predictions were printed on the same page. "Head Counselor" predictions were filled in by hand on a rating form, which was then photoreproduced and stapled to the cum.

The cums for each counselor were assembled in three packets. The first packet contained the 20 cums with no predictive information; the second contained the 40 cums with computer predictions (both optimistic and pessimistic); the third contained the 40 cums with counselor predictions (both optimistic and pessimistic).

Counselors were instructed (See Appendix B) to examine each of the 100 cums and to record the letter grade they thought most likely for each student.

III. RESULTS

All of the subjects made predictions for all 100 cums. The mean predicted marks for each subject under each information condition are given in Table I. (Subject #6 deduced that there were in fact five copies of only 20 unique cums, and made identical predictions for each occurrence of each cum; consequently, we have eliminated his data from all analyses except where explicitly noted.) The No Prediction condition is of particilar interest because it gives the subjects' predictions without the influence of any added information. All 10 counselors tended to predict higher marks than those actually received by the students; this may reflect a general reluctance on the counselors' part to discourage students from taking courses even when some predictive signs are negative.

Table II shows the correlations among counselors for the No Prediction case and their correlations with the grades actually received. The correlations among counselors show good agreement. Correlations with the actual grades are generally lower, and two--those for subjects #4 and #5--are not significant at the .05 level.

We used a multiple linear regression method to examine differences among treatments. We might have used analysis of variance, which is a special case of this method, but we chose not to because the regression method allows us to state our problem and hypothesis in a more rigorous and generalized fashion. Bottenberg and Ward have written a detailed description of the method, and Ward has published a comparison between this method and other approaches.[1]

The dependent variable was defined to be a vector Y containing all the subjects' predictions of ninth-grade algebra marks. Nine subjects, each making judgments on 100 cums, give Y a dimension of 900.

Independent variables were defined as the following vectors where

$i = 1, 2, \ldots, 900.$

X_1: The i-th element of X_1 equals 1 if the corresponding element of Y was a judgment on a cum for which the subject had no additional information; otherwise, the i-th element equals 0.

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[1] Bottenberg, R. A. and Ward, J. H. Applied Multiple Linear Regression, PRL-TDR-63-6, March, 1963, 6570th Personnel Research Laboratory, Lackland Air Force Base, Texas; Ward, J. H. "Synthesizing Regression Models--An Aid to Learning Effective Problem Analysis," The American Statistician, April 1969, XXIII, No. 2.

TABLE I. MEAN PREDICTION *

Subject	No Prediction	Computer Optimistic	Computer Pessimistic	Counselor Optimistic	Counselor Pessimistic
1	2.20	2.40	1.95	2.45	1.85
2	2.35	2.25	1.65	2.50	1.80
3	2.65	2.75	2.05	2.55	2.05
4	2.15	2.10	1.95	2.20	2.05
5	2.35	2.40	2.05	2.50	2.05
6	2.35	(2.35)	(2.35)	(2.35)	(2.35)
7	2.30	2.65	1.85	2.55	1.95
8	2.25	2.60	2.35	2.70	2.45
9	3.00	2.90	2.25	2.75	2.15
10	2.25	2.55	1.90	2.45	1.95
Mean	2.425	2.495	2.035	2.500	2.065
(Without #6)	2.433	2.511	2.000	2.510	2.033

* (Coded: A=4, B=3, C=2, D=1, F=0)

COUNSELORS

	1	2	3	4	5	6	7	8	9	10	Act
1		.8135	.8080	.8813	.7043	.8982	.7421	.8907	.7833	.8323	.6812
2			.8213	.7536	.7165	.9052	.7759	.8510	.6815	.9503	.5443
3				.6996	.7130	.8213	.6673	.8183	.7141	.8357	.5988
4					.6078	.8483	.6075	.8510	.6815	.7176	.4354
5						.7165	.5990	.6693	.6976	.7921	.3120
6							.7158	.8510	.7789	.8727	.5443
7								.7113	.7414	.7630	.5126
8									.6822	.7984	.5721
9										.7171	.5590
10											.5345
Act											

TABLE II. CORRELATIONS--NO PREDICTION CASE

X_2: The i-th element equals 1 if the corresponding element of Y was a judgment on a cum for which the subject was given an optimistic computer prediction, and 0 otherwise.

X_3: The i-th element equals 1 if the corresponding element of Y was a judgment on a cum for which the subject was given a pessimistic computer prediction, and 0 otherwise.

X_4: The i-th element equals 1 if the corresponding element of Y was a judgment on a cum for which the subject was given an optimistic counselor prediction, and 0 otherwise.

X_5: The i-th element equals 1 if the corresponding element of Y was a judgment on a cum for which the subject was given a pessimistic counselor prediction, and 0 otherwise.

Expressing Y as a linear combination of X_1, X_2, X_3, X_4, X_5 plus a residual vector E, we get

$$Y = w_1 X_1 + w_2 X_2 + w_3 X_3 + w_4 X_4 + w_5 X_5 + E \qquad (1)$$

where the w's are determined by the method of least squares.

Computation of the w's yields

$$w_1 = 2.3889,\ w_2 = 2.5111,\ w_3 = 2.0000,\ w_4 = 2.5167,\ w_5 = 2.0333,$$

and the sum of squares of the elements of E, or the residual in E, is 606.51. Note that the w_1, w_2, w_3, w_4, w_5 are actually the means of the five treatments--no prediction, computer optimistic, computer pessimistic, counselor optimistic, and counselor pessimistic, respectively.

Three null hypotheses were tested, as described in the following paragraphs.

Hypothesis 1. There are no differences in expected counselors' judgments among the five different treatments. In terms of model (1) this means that we hypothesize that $w_1 = w_2 = w_3 = w_4 = w_5 = a$, a constant for all treatments. Imposing this restriction on model (1) we get

$$Y = aX_1 + aX_2 + aX_3 + aX_4 + aX_5 + G$$

Hence,

$$Y = a(X_1 + X_2 + \ldots + X_5) + G$$

where G is a new residual vector.

Let $U = X_1 + X_2 + \ldots + X_5$; U will be a vector containing all 1's. Then

$$Y = aU + G \qquad (2)$$

The method of least squares gives

$$a = 2.29$$

and a residual in G of 653.31 for model (2). The constant, a, is the mean across all treatments.

The f-statistic is then computed as follows:

$$f = \frac{(653.31 - 606.51)/4}{606.51/895} = 17.27$$

where 4 and 895 are, of course, the degrees of freedom for the numerator and denominator, respectively. This f is significant with $p < .001$. Therefore, we reject the hypothesis and continue our analysis using model (1).

Hypothesis 2. There is no difference between expected counselors' judgments if they are given an optimistic prediction or a pessimistic prediction.

Mathematically, the hypothesis is

$$w_1 = b_1,\ w_2 = w_3 = b_2 \text{ and } w_4 = w_5 = b_3$$

where b_1, b_2 and b_3 are constants.

Model (1) then becomes

$$Y = b_1 X_1 + b_2 X_2 + b_2 X_3 + b_3 X_4 + b_3 X_5 + H$$

Hence

$$Y = b_1 X_1 + b_2 (X_2 + X_3) + b_3 (X_4 + X_5) + H$$

where H is the new residual vector.

Let $C_1 = X_1$, $C_2 = X_2 + X_3$, and $C_3 = X_4 + X_5$; then

$$Y = b_1 C_1 + b_2 C_2 + b_3 C_3 + H \qquad (3)$$

The solution of this model gives

$$b_1 = 2.3889,\ b_2 = 2.5139,\ b_3 = 2.0167$$

and the residual in H is 651.04.

For this hypothesis,

$$f = \frac{(651.04 - 605.51)/2}{606.51/895} = 32.86$$

which is significant with $p < .001$. We, therefore, reject the hypothesis and can expect different judgments from a counselor when he is given an optimistic prediction then when he is given a pessimistic prediction.

We now continue our analysis of model (1).

Hypothesis 3. There is no difference between expected counselors' judgments if they are given a computer's prediction or a counselor's prediction. In terms of model (1) this says that

$$w_1 = c_1,\ w_2 = w_4 = c_2,\ \text{and}\ w_3 = w_5 = c_3$$

where c_1, c_2, and c_3 are new constants. Therefore we have

$$Y = c_1 X_1 + c_2 X_2 + c_3 X_3 + c_2 X_4 + c_3 X_5 + I$$

where I is the new residual vector.

$$Y = c_1 X_1 + c_2 (X_2 + X_4) + c_3 (X_3 + X_5) + I$$

Let $D_1 = X_1$, $D_2 = X_2 + X_4$, and $D_3 = X_3 + X_5$; then

$$Y = c_1 D_1 + c_2 D_2 + c_3 D_3 + I \qquad (4)$$

The least squares solution is

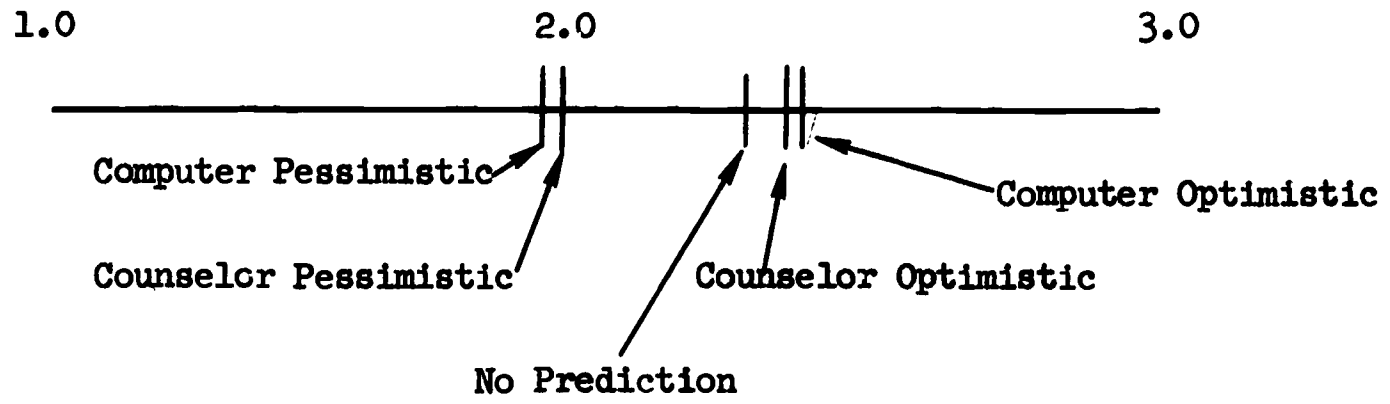
$$c_1 = 2.3889,\ c_2 = 2.2256,\ c_3 = 2.2750$$

and the residual in I is 606.61. Computation of the f-statistic gives

$$f = \frac{(606.61 - 606.51)/2}{606.51/895} = 0.07$$

which is not significant. Hence, we accept hypothesis 3--model (4)-- and conclude that counselors do not make different judgments when they are given a computer prediction and when they are given a head counselor's prediction.

The following diagram represents the situation graphically.



This diagram should be interpreted with three reference points in mind. The midpoint, 2.0, is the mean of the actual marks made by the students in ninth grade algebra. The left endpoint, 1.0, is the mean of the pessimistic predictions given the counselors, and the right endpoint, 3.0, is the mean of the optimistic predictions given the counselors.

If we examine the diagram, we see that counselors on the average were optimistic in their predictions, being about .4 units above the actual of 2.0. If they were given an optimistic prediction, they were swayed slightly, about .1 of a unit, to the right. Given a pessimistic prediction, they were swayed more--about .4 of a unit. That is, their average pessimistic prediction was nearer the actual than their unassisted prediction. In no case were they swayed heavily, by either a computer's or another counselor's prediction.

IV. CONCLUSIONS

We have observed that counselors tend to be optimistic in their predictions. This style of prediction certainly supports the idea of "giving the student the benefit of the doubt." One might wonder, however, if this style also increases the number of failures since the counselors would be allowing "unqualified" students to enroll in algebra. This is probably true, but the situation is complicated by the common practice of teachers to assign grades on a normal distribution basis. If the ninth grade algebra teachers follow this rule, then there will not only be more F's, but more A's. The percentage of A's and F's would remain constant no matter what predictive method the counselors use. This makes one question the rationality of having a prediction system of any kind.

Although there were differences in the subjects' predictions among the different treatments (we rejected hypothesis 1), two conclusions may be drawn:

1. Counselors' predictions are swayed differently by optimistic and pessimistic predictions (we rejected Hypothesis 2).

(Page 13 Blank

2. Counselors' predictions are not swayed differently if they are given a computer's prediction or a head counselor's prediction (we accepted Hypothesis 3).

These conclusions accord with common sense. If a counselor is given additional information to make a prediction, he would be expected to use it and be swayed, at least slightly, by it. On the other hand, not one counselor asked us how accurate the additional information was. In fact, the predictions we gave them were 100% incorrect (each prediction differed by one letter grade from the actual one).

We were rather pleased that the counselors were not affected differently by the computer and head counselor. One of the motivations for this study was a concern we had that counselors might worship any information that a computer gave them. But the counselors we tested apparently believed that information was just information, whether it came from a machine or a head counselor.

APPENDIX A

GENERATED CUMS

This appendix contains examples of the information given to the subjects. The cums actually used by the counselors were printed by a high-speed printer, thus giving the cums a "computer look." The first example is for the No Prediction case; the second is an example of the computer optimistic case; the third, the counselor optimistic case.

STUDENT NO. 000001

DAT TEST PROFILE 6-68

VERB REAS	500
MECH REAS	050
SENTENCES	150
NUM ABIL	500
ABS REAS	350
SPAT REL	550
CLERICAL	050
SPELLING	250
TOT(VRNA)	500

COURSE TITLE	MARK	CREDIT	DATE
ENGLISH 7	C	5	2-67
MATH 7	C	5	2-67
GEOGRAPHY	C	5	2-67
HOMEMAKING	B	5	2-67
GIRLS P.E.	A	5	2-67
FINE ARTS	B	5	2-67
ENGLISH 7	B	5	6-67
MATH 7	D	5	6-67
GEOGRAPHY	B	5	6-67
HOMEMAKING	B	5	6-67
GIRLS P.E.	A	5	6-67
FINE ARTS	A	5	6-67
SPEECH/DRAMA	B	5	2-68
ENGLISH 8	B	5	2-68
MATH 8	B	5	2-68
SCIENCE 8	A	5	2-68
US HISTORY	B	5	2-68
GIRLS P.E.	B	5	2-68
CHORUS	B	5	2-68
GP. GUID 8	B	5	2-68
SPEECH/DRAMA	A	5	6-68
ENGLISH 8	B	5	6-68
SCIENCE 8	B	5	6-68
US HISTORY	B	5	6-68
GIRLS P.E.	B	5	6-68
CHORUS	B	5	6-68
GP. GUID 8	B	5	6-68

STUDENT NO. 00002

COMPUTER PREDICTION FOR ALGEBRA 9 MARK = B

DAT TEST PROFILE	6-68
VERB REAS	700
MECH REAS	800
SENTENCES	200
NUM ABIL	500
ABS REAS	750
SPAT REL	650
CLERICAL	450
SPELLING	450
TOT (VRNA)	650

COURSE TITLE	MARK	CREDIT	DATE
ENGLISH	B	5	2-67
MATH 7	C	5	2-67
SCIENCE	B	5	2-67
GEOGRAPHY	C	5	2-67
SPANISH	A	5	2-67
GIRLS P.E.	B	5	2-67
HOMEMAKING	B	5	2-67
FINE ARTS	A	5	2-67
ENGLISH	B	5	6-67
MATH 7	C	5	6-67
SCIENCE	C	5	6-67
GEOGRAPHY	C	5	6-67
SPANISH	A	5	6-67
GIRLS P.E.	C	5	6-67
HOMEMAKING	C	5	6-67
FINE ARTS	A	5	6-67
ENGLISH 8	A	5	2-68
MATH 8	B	5	2-68
SCIENCE 8	B	5	2-68
US HISTORY	C	5	2-68
GIRLS P.E.	B	5	2-68
ART/MUSIC APP	A	5	2-68
GP. GUID 8	A	5	2-68
STUDENT SERV	A	5	2-68
SPEECH/DRAMA	A	5	6-68
ENGLISH 8	C	5	6-68
MATH 8	B	5	6-68
SCIENCE 8	C	5	6-68
US HISTORY	B	5	6-68
GIRLS P.E.	B	5	6-68
ART/MUSIC APP	A	5	6-68
GP. GUID 8	A	5	6-68

STUDENT NO. 000063

DAT TEST PROFILE 6-68

VERB REAS	500
MECH REAS	750
SENTENCES	400
NUM ABIL	700
ABS REAS	030
SPAT REL	650
CLERICAL	150
SPELLING	400
TOT (VRNA)	600

COURSE TITLE	MARK	CREDIT	DATE
ENGLISH 7	C	5	2-67
MATH 7	B	5	2-67
SCIENCE	B	5	2-67
GEOGRAPHY	B	5	2-67
SPANISH	C	5	2-67
IND ARTS	C	5	2-67
BOYS P.E.	B	5	2-67
ENGLISH 7	C	5	6-67
MATH 7	C	5	6-67
SCIENCE	C	5	6-67
GEOGRAPHY	B	5	6-67
SPANISH	C	5	6-67
IND ARTS	B	5	6-67
BOYS P.E.	B	5	6-67
SPEECH/DRAMA	A	5	2-68
ENGLISH 8	C	5	2-68
MATH 8	A	5	2-68
SCIENCE 8	B	5	2-68
US HISTORY	B	5	2-68
IND. ARTS	A	5	2-68
BOYS P.E.	B	5	2-68
GP. GUID 8	B	5	2-68
SPEECH/DRAMA	A	5	6-68
ENGLISH 8	B	5	6-68
MATH 8	A	5	6-68
SCIENCE 8	A	5	6-68
US HISTORY	A	5	6-68
IND. ARTS 8	B	5	6-68
BOYS P.E.	A	5	6-68
GP. GUID 8	C	5	6-68

APPENDIX B

INSTRUCTIONS FOR SUBJECTS

Under a contract with the U. S. Office of Education, System Development Corporation is conducting a study of how counselors make predictions. We are particularly interested in finding out what kinds of information are most helpful to counselors when they make predictions. Your cooperation in this study can help us make recommendations about the kinds of information which should be provided to counselors in order to improve the accuracy of their predictions.

What we will ask you to do is make your best prediction about success in ninth grade algebra for 100 eighth grade students. You will be given data about each student on which to base your prediction. These data will be of three kinds:

1. An abbreviated copy of the student's cum containing aptitude test scores, and courses and marks for the 7th and 8th grade.

2. A prediction made by an electronic computer. This computer prediction is based on information from the cum, teachers' recommendations, a special math readiness test, and the results of an interview with the student.

3. A prediction of success in algebra made by the student's counselor who had the same information supplied to the computer and also knew the student.

Because we want to find out what kind of information helps you most, we will not give you all three kinds of information for every student. For some students you will receive only the abbreviated cum. For others you will get the cum and the counselor's prediction. For still another group you will receive the cum and the computer prediction.

What you should do is look at the information for each student, case by case, and make your prediction. In the lower left hand corner of the cum, write the letter grade you think the student would be most likely to earn if he took algebra in the ninth grade. You may use, or ignore, any part of the information that you choose and should employ whatever decision logic you believe to be appropriate.

We realize that it is difficult to predict a letter grade for a student. However, in order to get the most out of this investigation, we do ask you to do the best prediction job that you can and to write one and only one letter grade on each cum.

Remember, there are 100 cases and so you should work rapidly. Still, in order to make this study meaningful you should give each case the consideration it deserves.

Thank you for your cooperation.

Counselor _____ Student Number 63

If this 8th grade student were to take algebra in the 9th grade, what do you think his mark would most likely be? (Please check only one.)

_____A

_____B

_____C

_____Below C (student should not take algebra in the 9th grade.)